[Supplementary material]

Patterns of dietary diversity in Holocene north-west South America: new insights from Bayesian stable isotope mixing models

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Human samples investigated

Early Holocene

The Early Holocene (EH) sample is composed by 17 individuals (nine males, five females and three undetermined) representing generalised foragers derived from several archaeological sites located in distinct environmental settings (open air sites and rock-shelters). The chronological range is from *c*. 9000 cal BP (Rodríguez 2011; human bone Beta-299693 [7950±40 BP] 8977–8880 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020) to *c*. 7000 cal BP (Orrantia 1997; human bone Beta-104490 [5910±70] 6880–6872 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020). One male skeleton from La Floresta site (2500m asl) which was recovered during the 1940s and dated in 2011 (Rodríguez 2011) was included. Eleven human skeletons (five males, three females and three undetermined) from the multicomponent site Tequendama I and II also were investigated. This rock shelter (2570m asl) was occupied since the final Pleistocene until the late Holocene (Correal & van der Hammen 1977). The chronological range of the skeletons here included goes from *c*. 7850–7000 cal BP. Additionally, two skeletons (one male and one female) from the open air site Checua I (2950m asl) were investigated (Groot 1992). Checua is also a multicomponent open air site and the early Holocene burials are concentrated in strata 4 and 5 whose chronological range is between 9000 and 8200 cal BP. Another male skull was included from the open air site Galindo I (2598m asl) which was found in the Level 2 dated in 8520–8390 cal BP (Pinto 2003; charcoal GrN-16345 [7730±60 BP]; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020). Finally, two skulls (a male and a female) from the open air site Potreroalto

(2610m asl) were also included (Orrantia 1997). Both individuals were radiocarbon dated by the AMS technique (Orrantia 1997; human bone, Beta-104490 [5910±70 BP] 6880–6872 cal BP at 95.4% and human bone, Beta-104491 [6830±110 BP] 7850–7450 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020). Some old radiocarbon dates derive from human bone and therefore were corrected by isotopic fractionation (Delgado 2015). Two additional individuals with high carbon of alleged early chronology (Triana 2019), were here considered belonging to the initial late Holocene period according to the original reports (Correal & van der Hammen 1977; van der Hammen *et al*. 1990).

Middle Holocene

The middle Holocene (MH) sample is integrated by 25 individuals (seven males, eight females and 10 undetermined) derived from four open air archaeological sites (Checua, Aguazuque, Ubaté and Bonaca) representing generalised foragers and early horticulturalists. The chronological range is from *c*. 6400 cal BP (Rodríguez 2011; human bone Beta-278827 [5770±40 BP] 6400–6280 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020) to *c*. 4200 cal BP (Correal 1990; human bone GrN-14478 [3850±35] 4250–4150 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020). Aguazuque (2613m asl) is an open air site that presented multiple occupations which span from *c*. 5900 cal BP to *c*. 2800 cal BP (Correal 1990). This site covers the transition from horticulturalists to agriculturalists. A total of 16 individuals (four males, six females and six undetermined) from this site were included in the present study with dates that range from *c*. 5750 cal BP to *c*. 4250 cal BP. All radiocarbon dates derived from human bone and therefore were corrected by isotopic fractionation (Delgado 2015). Additionally, 6 individuals (two males, two females and two undetermined) were investigated from the open air site Ubaté (2550m asl) whose radiocarbon dates ranges from *c*. 6400–6150 cal BP (Archila & Langebaek 2015). This site covers the transition from foragers to horticulturalists. One male from the open air site Checua above described was also included dated at *c*. 6400 cal BP (Rodríguez 2011). Finally, two additional undetermined individuals were included from the open air site Bonaca (2610m asl) whose dates were established at *c*. 6300 and *c*. 6150 cal BP (Delgado *et al*. 2021).

Initial Late Holocene

The sample corresponding to this period (ILH) is composed by 11 individuals (four males, three females and four undetermined) from three archaeological sites which represent foragers, horticulturalists and agriculturalists. The chronological range is from *c*. 3800 cal BP to *c*. 2290 cal BP. Three individuals (two males and one female) are from the upper strata of the Tequendama rock shelter described above. There are no radiometric ages for these levels but the strata where these skeletons were correlated with radiocarbon dated strata from other nearby archaeological site named Zipacón (Correal & Pinto 1983; faunal bone GrN-11125 [3270±30] 3600-3525 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020) indicating that the date of *c*. 3800 cal BP better characterises the upper chronological limit for this period. Six individuals are from the upper levels from the Aguazuque site mentioned above dated at 2725±35 (Correal 1990; GrN-14479: 2850–2750 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020). Lastly, an individual (male) from the Madrid site was included which corresponds to the lower chronological limit for this period is represented by the date 2100±50 (Rodríguez & Cifuentes 2005; human bone Beta-204120: 2290-2280 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020).

Final Late Holocene

The final Late Holocene sample is composed by 93 individuals (38 males, 22 females and 33 undetermined). Such data derived from four sites (2600m asl) namely Las Delicias (two males, one female and five undetermined) (Cárdenas 1993); Tibanica (20 males, 10 females and 28 undetermined) (Delgado *et al*. 2014; Delgado 2018); Portalegre (four males and two females) (Cárdenas 2002) and Candelaria (12 males, seven females and two undetermined) (Cárdenas 1996). Despite the Muisca period has been traditionally divided into early (*c*. 1200–800 cal BP) and late periods (*c*. 700–350 cal BP), here, both periods were grouped covering the last 1200 years BP. The chronological range is from *c*. 1250 cal BP (Enciso

1990–1991; charcoal Beta-39874 [1180±70 BP] 1280–925 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020) to *c*. 550 cal BP (Miller 2016; human bone KC-2208 [640±20] 650–550 cal BP at 95.4%; date modelled in rcarbon 1.2.0 using SHCal13 calibration curve; Bevan & Crema 2020). The Muisca settlements represent specialised agriculturalist societies which reached the highest sociocultural development, political complexity and population size previous to the European invaders arrival (Delgado *et al*. 2014).

Methods

The human dataset was compiled from reports derived from distinct laboratories including the Biology Department, Augustana College USA; the Research Laboratory for Archaeology and the History of Art, Oxford, UK; Beta Analytic Inc.; Department of Geography, University of Leicester, UK; Instituto de Geología, Universidad Nacional Autónoma de México and Center for Stable Isotope Biogeochemistry (CSIB) at UC Berkeley. The radiocarbon dates were calibrating using the R package rcarbon 1.2.0 using the SHCal13 calibration curve (Bevan & Crema 2020) at 2σ (95.4% probability). Scatterplots comparing carbon (collagen) and nitrogen isotopes and carbon (collagen and apatite) isotopes were performed in R 3.6.1 (R Core Team 2019) using the package ggplot2 (Wickham 2016). Isotopic average values were expressed as medians and their associated standard errors (uncertainties). Following Fernandes *et al*. (2015) the standard error of the mean, rather than the standard deviation, was reported given that human long bones integrate food isotopic signals during multiyear sampling periods (Hedges *et al*. 2007). The Bayesian mixing model FRUITS (Food Reconstruction Using Isotopic Transferred Signals version 2.1.1; Fernandes *et al*. 2014) was used to model human diets across all periods investigated. It allows handling distinct uncertainties, such as isotopic composition of potential food groups, diet-to-tissue offsets and dietary routing (Fernandes *et al*. 2014, 2015; Fernandes 2016; Killian Galván 2018). This model presents two important advantages over other BMMs, beyond its user-friendly interface, in that account for possible dietary routing mechanisms and provide a very simple method to input diverse sources of prior information derived from a number of previous studies (e.g. physiologic, metabolic etc.) (Fernandes *et al*. 2014).

Four main food groups were considered in the present study (Tables S2 and S3): terrestrial C_3 and C_4 plants and meat for terrestrial C_3 and C_3/C_4 animals. C_3 plants include fruits, highland tubercles, cucurbits, potato and peppers while C_4 plants only include maize. Values for C_3 plants were averaged to be used in FRUITS. C_3 animals include deer (*Odocoileus virginianus*) and guinea pigs (*Cavia porcellus*). These animals represent the main faunal resources consumed at the SB region over the Holocene period. C_4 animals comprise birds (undetermined), dog (*Canis familiaris*), margay (*Leopardus wiedii*) and two guinea pig (*Cavia porcellus*) and rabbit (*Sylvilagus brasiliensis*) samples with high carbon values. The carbon and nitrogen isotopic composition of these resources was obtained from previous studies. The nutrient content (protein, carbohydrates and lipids) of the plants investigated was expressed as dry weight carbon content (wtC%), with carbohydrates and lipids combined into a single fraction. For the estimation of macronutrient composition of foods, the Supporting Materials (arcm12193-sup-0001-supplementary) in Fernandes (2016) was used (FAOSTAT 2009).

The isotope values of terrestrial animals investigated were estimated from bone collagen values, relying on previously reported offsets between macronutrient and collagen isotopic values for these animals (Fernandes 2016; Killian Galván 2018). Chosen offsets for terrestrial animals were: $\delta^{13}C_{protein-collagen}$ −2‰; $\delta^{13}C_{lipids-collagen}$ −8‰; $\delta^{15}N_{protein-collagen}$ +2‰, with an uncertainty of 1‰. As $\delta^{13}C_{apatite}$ is a dietary proxy that signals the carbon of the dietary mix, the $\delta^{13}C$ signal of each food group was that of the bulk carbon. Terrestrial animals $\delta^{13}C$ bulk values were estimated as a weighted mean (in accordance with nutrient composition) of lipid and protein $\delta^{13}C$ values. Bulk isotope plant values were adjusted for isotope offsets between bulk $\delta^{13}C$ values and protein (−2‰), and between bulk $\delta^{13}C$ values and carbohydrates (*c*. +0.5‰) (Tieszen 1991; Fernandes 2016; Killian Galván 2018). Diet-to-collagen, and diet-to-apatite, $\delta^{13}C$ isotope offsets were based on Fernandes *et al*. (2012), an offset of 4.8±0.2‰ for the former, and an offset of 10.1±0.2‰ for the latter, with a conservative uncertainty (0.5‰) to account for the possible effect of body size (Passey *et al*. 2005). Also, collagen carbon was routed from 74±4% dietary protein carbon, and the remaining 26 per cent from carbohydrates and lipids (as showed by Fernandes *et al*. 2012; Killian Galván 2018).

For human $\delta^{15}N$ diet-to-collagen isotope offset a value of 5.5±0.5‰ was used (Fernandes 2016). Finally, based on existing studies the acceptable level of dietary protein intake was established between 5 and 45 per cent of protein carbon contribution (Otten *et al*. 2006; Fernandes *et al*. 2014; Killian Galván 2018).

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Table S1. Stable isotope descriptive statistics for chronological human samples investigated from the Sabana de Bogotá region. EH = Early Holocene; MH = Middle Holocene; ILH = initial Late Holocene; FLH = final Late Holocene.

Periods	Isotope	N	Median	Maximum	Minimum	Standard error
EH	$\delta^{13}C_{collagen}$	17	−20.1	−14.7	−21.9	0.3
	$\delta^{15}N_{collagen}$	17	7.3	10.0	5.6	0.3
	$\delta^{13}C_{apatite}$	12	−14.0	−10.0	−16.4	0.5
MH	$\delta^{13}C_{collagen}$	25	−19.9	−18.4	−21.0	0.1
	$\delta^{15}N_{collagen}$	25	8.0	11.2	5.5	0.2
	$\delta^{13}C_{apatite}$	7	−14.7	−12.9	−15.5	0.3
ILH	$\delta^{13}C_{collagen}$	11	−15.8	−10.5	−20.3	1.1
	$\delta^{15}N_{collagen}$	11	8.9	10.0	6.8	0.3
	$\delta^{13}C_{apatite}$	5	−13.3	−8.8	−15.2	1.1
	$\delta^{13}C_{collagen}$	93	−11.8	−8.4	−15.8	0.1
FLH	$\delta^{15}N_{collagen}$	93	9.7	12.1	8.3	0.1
	$\delta^{13}C_{apatite}$	93	−6.9	−4.1	−8.9	0.1

Table S2. Stable isotope descriptive statistics for zooarchaeological samples investigated from the Sabana de Bogotá region.

Groups	Isotope	N	Median	Maximum	Minimum	Standard error
C_3 animals	$\delta^{13}C_{collagen}$	11	−19.2	−17.9	−20.3	0.2
	$\delta^{13}C_{apatite}$	11	−10.1	−8.3	−12.1	0.4
	$\delta^{15}N_{collagen}$	11	4.1	6.0	2.6	0.4
C_3/C_4 animals	$\delta^{13}C_{collagen}$	6	−14.6	−9.9	−17	0.2
	$\delta^{13}C_{apatite}$	6	−9.3	−3.8	−11.5	0.5
	$\delta^{15}N_{collagen}$	6	8.9	9.6	7.3	0.5

Table S3. Stable isotope descriptive statistics for C_3 and C_4 plant samples investigated from the Sabana de Bogotá region.

Plants groups	Isotope	N	Median	Maximum	Minimum	Standard error
C_3 fruits	$\delta^{13}C_{collagen}$	7	−24.7	−20.4	−26.4	0.7
	$\delta^{15}N_{collagen}$	7	8.5	10.2	4.7	1.0
C_3 tubercles	$\delta^{13}C_{collagen}$	15	−24.4	−20.9	−27.7	0.7
	$\delta^{15}N_{collagen}$	15	2.9	3.8	1.3	0.1
Capsicum	$\delta^{13}C_{collagen}$	3	−26	−25.4	−27.9	0.7
	$\delta^{15}N_{collagen}$	3	5.7	7.2	4.3	0.8
Cucurbits	$\delta^{13}C_{collagen}$	9	−24.1	−19.4	−26	1.2
	$\delta^{15}N_{collagen}$	9	1.3	6.2	−1.9	1.7
Potato	$\delta^{13}C_{collagen}$	6	−22.8	−20.2	−24.0	0.6
	$\delta^{15}N_{collagen}$	6	11	13.0	9.9	1.1
Maize	$\delta^{13}C_{collagen}$	3	−10.7	−10.6	−10.8	0.05
	$\delta^{15}N_{collagen}$	3	8.2	8.3	8.2	0.02

Table S4. Estimates generated by FRUITS of the average calorie contribution of each food group (Food %) for the alternative Early Holocene 2 (EH2) model ((C_3 plants = C_3 animals)).

Period	Food group	Mean	SD	2.5pc	Median	97.5pc
	C_3 animals	0.021	0.018	0.935	0.015	0.064
EH2	C_3/C_4 animals	0.940	0.040	0.847	0.950	0.992
	C_3 plants	0.021	0.018	0.001	0.015	0.064
	C_4 plants	0.018	0.016	0.465	0.013	0.060

Table S5. Estimates generated by FRUITS of the average calorie contribution of each food group (Food %) for the alternative Early Holocene 3 (EH3) model ([C_3 plants>C_3 animals]).

Period	Food group	Mean	SD	2.5pc	Median	97.5pc
	C_3 animals	0.479	0.028	0.424	0.481	0.532
EH3	C_3/C_4 animals	0.008	0.007	0.236	0.006	0.027
	C_3 plants	0.450	0.026	0.393	0.453	0.491
	C_4 plants	0.063	0.045	0.003	0.057	0.160

Table S6. Estimates generated by FRUITS of the average calorie contribution of each food group (food %) for the alternative final Late Holocene 2 (FLH2) model ([C_3 plants = C_3 animals]).

Period	Food group	Mean	SD	2.5pc	Median	97.5pc
	C_3 animals	0.022	0.018	0.001	0.017	0.062
FLH2	C_3/C_4 animals	0.027	0.025	0.593	0.020	0.090
	C_3 plants	0.929	0.043	0.838	0.937	0.991
	C_4 plants	0.022	0.018	0.001	0.017	0.062

Table S7. Estimates of the calorie contribution from each food fraction for each period. EH = Early Holocene; MH = Middle Holocene; ILH = initial Late Holocene; FLH = final Late Holocene.

Period	Fraction	Mean	SD	2.5pc	median	97.5pc
	Protein	0.043	0.006	0.030	0.045	0.050
EH	Energy	0.448	0.009	0.431	0.448	0.466
	Bulk	0.508	0.009	0.491	0.508	0.525
	Protein	0.043	0.006	0.029	0.045	0.050
MH	Energy	0.448	0.009	0.431	0.449	0.467
	Bulk	0.507	0.009	0.491	0.507	0.525
	Protein	0.042	0.006	0.027	0.044	0.050
ILH	Energy	0.433	0.011	0.412	0.433	0.456
	Bulk	0.524	0.011	0.503	0.525	0.546
	Protein	0.042	0.006	0.029	0.044	0.050
FLH	Energy	0.351	0.014	0.323	0.352	0.377
	Bulk	0.605	0.014	0.581	0.605	0.635

Table S8. Estimates of calorie contribution from each food group towards each dietary proxy investigated ($\delta^{13}C_{collagen}$, $\delta^{15}N_{collagen}$ and $\delta^{13}C_{bioapatite}$). EH = Early Holocene; MH = Middle Holocene; ILH = initial Late Holocene; FLH = final Late Holocene.

Period	Proxy	Source/food	Mean	SD	2.5pc	median	97.5pc
	$\delta^{13}C_{collagen}$	C_3 animals	0.064	0.053	0.002	0.050	0.193
	$\delta^{13}C_{collagen}$	C_3/C_4 animals	0.030	0.028	0.001	0.022	0.104
	$\delta^{13}C_{collagen}$	C_3 plants	0.882	0.059	0.744	0.890	0.972
	$\delta^{13}C_{collagen}$	C_4 plants	0.024	0.018	0.920	0.020	0.069
	$\delta^{15}N$	C_3 animals	0.142	0.116	0.004	0.114	0.423
EH	$\delta^{15}N$	C_3/C_4 animals	0.069	0.062	0.002	0.051	0.235
	$\delta^{15}N$	C_3 plants	0.758	0.124	0.473	0.775	0.947
	$\delta^{15}N$	C_4 plants	0.031	0.027	0.001	0.025	0.099
	$\delta^{13}C_{apatite}$	C_3 animals	0.044	0.037	0.001	0.034	0.134

	$\delta^{13}C_{apatite}$	C_3/C_4 animals	0.021	0.019	0.712	0.016	0.072
	$\delta^{13}C_{apatite}$	C_3 plants	0.889	0.051	0.775	0.894	0.972
	$\delta^{13}C_{apatite}$	C_4 plants	0.046	0.034	0.002	0.039	0.126
	$\delta^{13}C_{collagen}$	C_3 animals	0.059	0.051	0.002	0.044	0.186
	$\delta^{13}C_{collagen}$	C_3/C_4 animals	0.035	0.030	0.001	0.027	0.113
	$\delta^{13}C_{collagen}$	C_3 plants	0.884	0.056	0.758	0.892	0.972
	$\delta^{13}C_{collagen}$	C_4 plants	0.022	0.018	0.762	0.018	0.067
	$\delta^{15}N$	C_3 animals	0.132	0.110	0.004	0.102	0.402
MH	$\delta^{15}N$	C_3/C_4 animals	0.080	0.068	0.002	0.062	0.250
	$\delta^{15}N$	C_3 plants	0.760	0.119	0.494	0.777	0.947
	$\delta^{15}N$	C_4 plants	0.029	0.026	0.849	0.021	0.096
	$\delta^{13}C_{apatite}$	C_3 animals	0.041	0.035	0.001	0.031	0.129
	$\delta^{13}C_{apatite}$	C_3/C_4 animals	0.025	0.021	0.001	0.019	0.079
	$\delta^{13}C_{apatite}$	C_3 plants	0.893	0.048	0.788	0.898	0.972
	$\delta^{13}C_{apatite}$	C_4 plants	0.042	0.034	0.001	0.034	0.127
	$\delta^{13}C_{collagen}$	C_3 animals	0.055	0.048	0.001	0.041	0.179
	$\delta^{13}C_{collagen}$	C_3/C_4 animals	0.051	0.042	0.002	0.041	0.157
	$\delta^{13}C_{collagen}$	C_3 plants	0.802	0.067	0.664	0.807	0.920
	$\delta^{13}C_{collagen}$	C_4 plants	0.092	0.039	0.020	0.091	0.174
	$\delta^{15}N$	C_3 animals	0.124	0.106	0.004	0.096	0.395
ILH	$\delta^{15}N$	C_3/C_4 animals	0.117	0.093	0.004	0.094	0.347
	$\delta^{15}N$	C_3 plants	0.634	0.135	0.356	0.642	0.867
	$\delta^{15}N$	C_4 plants	0.125	0.069	0.019	0.117	0.283
	$\delta^{13}C_{apatite}$	C_3 animals	0.036	0.031	0.916	0.027	0.117
	$\delta^{13}C_{apatite}$	C_3/C_4 animals	0.033	0.027	0.001	0.026	0.103
	$\delta^{13}C_{apatite}$	C_3 plants	0.776	0.066	0.651	0.776	0.906
	$\delta^{13}C_{apatite}$	C_4 plants	0.155	0.060	0.037	0.157	0.270
	$\delta^{13}C_{collagen}$	C_3 animals	0.074	0.068	0.002	0.055	0.259
	$\delta^{13}C_{collagen}$	C_3/C_4 animals	0.060	0.050	0.002	0.046	0.187
	$\delta^{13}C_{collagen}$	C_3 plants	0.402	0.084	0.214	0.410	0.546
	$\delta^{13}C_{collagen}$	C_4 plants	0.465	0.053	0.362	0.464	0.575

	$\delta^{15}N$	C_3 animals	0.141	0.125	0.004	0.106	0.472
FLH	$\delta^{15}N$	C_3/C_4 animals	0.114	0.093	0.004	0.091	0.345
	$\delta^{15}N$	C_3 plants	0.326	0.103	0.137	0.322	0.538
	$\delta^{15}N$	C_4 plants	0.419	0.121	0.168	0.425	0.641
	$\delta^{13}C_{apatite}$	C_3 animals	0.036	0.032	0.944	0.027	0.124
	$\delta^{13}C_{apatite}$	C_3/C_4 animals	0.029	0.025	0.872	0.022	0.092
	$\delta^{13}C_{apatite}$	C_3 plants	0.280	0.069	0.134	0.283	0.407
	$\delta^{13}C_{apatite}$	C_4 plants	0.656	0.053	0.551	0.656	0.763